Claims

1. Detector module (1) for a Positron Emission Tomograph (PET) comprising
   - a matrix (3) of scintillator crystals (2), said matrix (3) having a first side and a second side opposite to said first side, each scintillator crystal (11) having a first end (14) and a second end (15), said scintillator crystals (2) being oriented parallel to each other, whereby said first end (14) and said second end (15) of each of said scintillator crystals (2) coincide with said first side and said second side of said matrix (3), respectively;
   - a first light sensitive detector (6) producing an electrical signal proportional to the amount of light detected, being optically connected to said first side of said matrix (3), said first light sensitive detector (6) being position sensitive; and
   - a second light sensitive detector (7) producing an electrical signal proportional to the amount of light detected, said second light sensitive detector (7) being optically connected to said second side of said matrix (3), being position sensitive.

2. Detector module (1) for a Positron Emission Tomograph (PET) according to claim 1, wherein said first light sensitive detector (6) and said second light sensitive detector (7) are segmented such that at least one segment in each of said light sensitive detectors (6, 7) corresponds to each of said scintillator crystals (2) in said matrix (3).

3. Detector module (1) for a Positron Emission Tomograph (PET) according to claim 2, wherein segmentation patterns of said light sensitive detectors (6, 7) match patterns of their respective matrix sides.

4. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the claims 1 to 3, wherein said first light sensitive detector (6) is a Hybrid Photo Diode (HPD) detector.

5. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the claims 1 to 4, wherein said second light sensitive detector (7) is a Hybrid Photo Diode (HPD) detector.

6. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the claims 1 to 5, wherein said matrix (3) has a rectangular pattern or a stonewall pattern with a first direction (y) parallel to one side of said rectangular pattern; said scintillator crystals (2) comprise a crystal material and an added crystal material length along said first direction (y) corresponds to about three times the absorption length of photons (γ_1, γ_2) with a primary photon energy to be detected in said crystal material.

7. Detector module (1) for a Positron Emission Tomograph (PET) according to claim 6, wherein said matrix (3) comprises 12 x 18 scintillator crystals (2).

8. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the above claims, wherein said crystal material comprises Cerium doped Yttrium Aluminum Perovskite (YAP:Ce).

9. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the claims 1 to 7, wherein said crystal material comprises Cerium doped Lutetium Oxyorthosilicate (LSO:Ce) or LuAP:Ce.

10. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the above claims, wherein said scintillator crystals (2) have the dimensions of 3.2 x 3.2 x 100 mm^3.

11. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the above claims, wherein said scintillator crystals (2) are spaced in said matrix (3) by wires strung between said scintillator crystals (2) close to said first and said second side of said matrix (3).

12. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the above claims, wherein said wires have a diameter of 0.8 mm.

13. Detector module (1) for a Positron Emission Tomograph (PET) as defined by claims 10 and 12, wherein said segments of said first and said second light detector (6, 7) have the dimensions of 4 mm x 4 mm.

14. Detector module (1) for a Positron Emission Tomograph (PET) according to any of the above claims, wherein said scintillator crystals (2) comprise crystal segments glued together with a glue having a matched refractive index as said crystal segments.

15. Positron Emission Tomograph (PET) scanner comprising a number of gamma detector modules (1) characterized in that said gamma detector modules each comprise a detector module (1) comprising
    - a matrix (3) of scintillator crystals (2), each scintillator crystal (11) having a first end (14) and a second end (15), said scintillator crystals (2) being oriented parallel to each other such that all mid points of said scintillator crystals (2) lie in one plane;
    - a first light sensitive detector (6) and a second light sensitive detector (7), each of said light sensitive detectors (6,7) produces an output signal proportional to the amount of light detected and is position sensitive;

    said number of gamma detector modules (1) are regularly angularly spaced on a first (51) and a second circle (52) around an axis (53) of said scanner and oriented such that all midpoints of said scintillator crystals (2) of said detector modules (1) lie in a symmetry plane perpendicular to said axis 53, whereby the spacing and distribution of said gamma detector modules (1) on said first and said second circle (51, 52) is such that there is no line of sight in a direction perpendicular to said axis (53) radial outward from the cross section of said axis (53) with said symmetry plane, such that there is practically a full azimuthal coverage.

16. Positron Emission Tomograph (PET) scanner according to claim 15, wherein said angular spacing between a first one of said gamma detector modules (1) being localized on said

first circle (51) to an adjacent second one of said gamma detector modules (1) localized on said second circle (52) is 15°.

17. Method for detecting the point of interaction of a gamma ray (γ_1, γ_2) within a detector module (1) comprising
   - a matrix (3) of scintillator crystals (2), each scintillator crystal having a first end (14) and a second end (15), said scintillator crystals (2) being oriented parallel to each other such that all mid points of said scintillator crystals (2) lie in a plane;
   - a fist light sensitive detector (6) and a second light sensitive detector (7), each of said light sensitive detectors (6, 7) produces an output signal proportional to the amount of light detected and is position sensitive;

   said detector module (1) having a coordinate system associated with, whereby two linear independent coordinate axes x and y span a xy-plane coinciding with said plane defined by said midpoints of said scintillator crystals (2) and a third coordinate axis z is oriented perpendicular to said plane whereby an origin of said coordinate system lies in said xy-plane and a positive direction of said coordinate axis z points to said first light sensitive detector (6), said method comprising the steps
   - determining the coordinates of said point of interaction in said xy-plane by identifying a first scintillator crystal being hit and using the known coordinates of said first scintillator crystal being hit in said xy-plain;
   - determining the coordinate of said point of interaction in said direction (z) perpendicular to said xy-plane by determining the amount of charge Q1 detected in said first light sensitive detector (6) and an amount of charge Q2 detected in said second light sensitive detector (7) within a coincidence time interval, where the coordinate z is given by $z = \frac{1}{2}[\lambda \ln \frac{Q_1}{Q_2} + L]$, where L is the length of said first scintillator crystal (11).

18. Method for detecting the point of interaction of a gamma ray (γ_1, γ_2) within a PET detector module (1) according to claim 17, wherein said determined coordinate is considered to be valid, if the total amount of charge (Q1 + Q2) detected by said first and said second light sensitive detectors (6, 7) equals a reference charge corresponding to a predetermined photon energy.

19. Method for detecting the point of interaction of a gamma ray (γ_1, γ_2) within a PET detector module (1) according to claim 17 or 18, where the determined coordinate is considered to be valid, if the total amount of charge (Q1 + Q2) detected by said first and said second light sensitive detectors (6, 7) originating from said first scintillator crystal (12) hit is lower than 60% of said reference charge, corresponding to said predetermined photon energy, and a second coordinate is determined according to the method of claim 18 in a same coincidence time interval, associated with a different scintillator crystal (13) hit and the charges detected by said first light sensitive detector (6) and said second light sensitive detector (7) originating from said different scintillator crystal (13) hit are Q3 and Q4, respectively, and the total amount of charges (Q1 + Q2 + Q3 + Q4) detected by said first light sensitive detector (6) and said second light sensitive detector (7) originating from said first scintillator crystal (12) hit and said different scintillator crystal (13) hit is about equal to said reference charge and said coordinate is closer to the source emitting the gamma ray than said second coordinate.

20. Single Photon Emission Computed Tomography detector comprising a photon detector characterized in that said photon detector is a detector module (1) for a Positron Emission Tomograph according to any of the claims 1 to 14.

21. Hybrid Photo Diodes (HPD) detector (6) comprising
    - a vacuum containment, said vacuum containment (4, 21, 22) having a flat entrance window (4) at a top and a base (22) at a bottom opposite to said top;
    - a semi transparent visible light bialkali photocathode (23) deposited inside said vacuum containment (4, 21, 22) at said top parallel to said entrance window (4);
    - a semiconductor sensor (8) mounted inside said vacuum containment (4, 21, 22) on said base (22), said semiconductor sensor (8) comprising segments;
    - a self triggering electronic circuitry for reading out each of said segments separately, being mounted inside said vacuum containment (4, 21, 22) at said base (22);
    - an electron optic (24,25) providing a 1:1 imaging of photo electrons from said semi-transparent visible light bialkali photocathode (23) onto said semiconductor sensor (8).

22. Hybrid Photo Diodes (HPD) detector (6) according to claim 21, wherein said base (22) comprises a ceramic material.

23. Hybrid Photo Diodes (HPD) detector (6) according to claims 21 or 22, wherein said semiconductor sensor (8) is a silicon sensor.

24. Hybrid Photo Diodes (HPD) detector (6) according to any of the claims 21 to 23, wherein said self triggering circuitry comprises
    one channel for each segment of said semiconductor sensor (8);
    a charge integrating preamplifier for each of said channels;
    a shaper for each of said channels; and
    a readout register for each of said channels.

25. Hybrid Photo Diodes (HPD) detector (6) according to claim 24, wherein said shaper has a tunable shaping time.

26. Hybrid Photo Diodes (HPD) detector (6) according to any of the claims 21 to 25, further comprising a parallel fast shaper circuit for producing a trigger signal for a readout logic.

27. Hybrid Photo Diodes (HPD) detector (6) according to any of the claims 21 to 26, wherein said electron optics comprise any suitable number of ring electrode (24, 25).

28. Hybrid Photo Diodes (HPD) detector (6) according to any of the claims 21 to 27, wherein said bialkali photocathode (23) is directly deposited on the inside of said entrance window (4).

29. Hybrid Photo Diodes (HPD) detector (6) according to any of the claims 21 to 28, where in said entrance window (4) is comprising sapphire.